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ABSTRACT TITLE: Ultrasonic/sonic drilling/coring (USDC) for in-situ planetary applications

AUTHOR LISTING: Yoseph Bar-Cohen^a, Stewart Sheritt^a, Benjamin Dolgin^a, Dharmendra Sign Pal^b and Thomas Peterson^b

^aJet Propulsion Laboratory, Caltech, Pasadena, CA 91109, yosi@jpl.nasa.gov

^bCybersonics, Inc., Erie, Pennsylvania, 16510-4703

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ABSTRACT TEXT

NASA's Mars and Solar System exploration missions are seeking regolith and rock samples from the depth down to 10m. Some mission require 100m and deeper penetrations. The environments that these instruments are expected to face range from cryogenic (Comets) to very hot and aggressive (Venus). Geological surveys from a lander of a rover require instrumented samplers to be placed at the end of a flexible arm or on a very-light rover. Low mechanical impact on the host is a major requirement for these samplers. Recently a ultrasonic/sonic drilling/coring (USDC) mechanism was developed that potentially allows meeting key challenges of planetary *in situ* sampling. It requires low preload (<5N) and power. It was shown to various rocks including granite, where a 2.5" thick construction brick was drilled in 5 minutes. It has a debris self-extracting mechanism via an ultrasonic transport up the drilling shaft. USDC is highly tolerant to misalignment even during drilling. The drilling/coring bit does not turn, thus, *in-situ* sensors can be integrated into the bit and also one can safely touch the USDC bit with one's bare hand during operation. The device can potentially be used as a tool for future human habitation on Mars or other planets and it can be tailored for operation in the harsh environments of these planets.

The USDC uses a floating head mechanism, where high frequency ultrasonic vibrations induced by a piezoelectric stack are used to create a hammering action. The floating head is a mechanical frequency transformer, and the drill bit operates with a combination of ultrasonic and sonic frequencies. This transformer converts the 20 kHz ultrasonic drive frequency to a combination of this high frequency drive signal and a 60-1000 Hz sonic hammering action. The drilling mechanism requires both of these frequencies to be present simultaneously. Finite element modeling and experiments that include drilling and coring of various types of rocks are currently under way. This paper discusses various aspects of design and testing of USDC.

KEYWORDS: Drilling, Ultrasonic/sonic, Coring, Piezoelectric, Actuators

BRIEF BIOGRAPHY: Dr. Yoseph Bar-Cohen is a physicist with over 28 years experience in NDE, sensors, actuators and electroactive materials. He is the Jet Propulsion Lab (JPL) Resident NDE expert and the Group Leader for the NDE& Advanced Actuators (NDEAA) Technologies. Also, he is an Adjunct Professor at the Department of the Mechanical and Aerospace Engineering, the University of California, Los Angeles (UCLA), a Fellow of the American Society for NDT (ASNT) and Chair of the ASNT's Ultrasonic Committee. Dr. Bar-Cohen is leading a NASA task to develop applications for EAP materials. Some of his contributions include his discoveries the leaky Lamb waves and the polar backscattering in composite materials and co-pioneered their applications to NDE. He is the author of more than 170 publications, made numerous presentations at national and international symposia and holds many patents.